

THE TICKS (ACARI: IXODIDA: ARGASIDAE, IXODIDAE) OF TAIWAN: A SYNONYMIC CHECKLIST

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Abstract.—Eleven checklists of Taiwanese ticks, published or privately circulated between 1935 and 1984, are compared with specimen records, chiefly in the U.S. National Tick Collection, yielding a list of 32 tick species thought to definitely occur in Taiwan and its adjacent islets: *Argas pusillus* Kohls, *A. robertsi* Hoogstraal, Kaiser & Kohls, *Ornithodoros capensis* Neumann, *Amblyomma cordiferum* Neumann, *A. geoemydae* (Cantor), *A. helvolum* Koch, *A. testudinarium* Koch, *Aponomma varanense* (Supino), *Boophilus microplus* (Canestrini), *Dermacentor taiwanensis* Sugimoto, *Haemaphysalis bandicota* Hoogstraal & Kohls, *H. canestrinii* (Supino), *H. doenitzi* Warburton & Nuttall, *H. flava* Neumann, *H. formosensis* Neumann, *H. hystricis* Supino, *H. kitaokai* Hoogstraal, *H. mageshimaensis* Saito & Hoogstraal, *H. ornithophila* Hoogstraal & Kohls, *H. phasiana* Saito, Hoogstraal & Wassef, *H. taiwana* Sugimoto, *H. yeni* Toumanoff, *Ixodes acutitarsus* (Karsch), *I. granulatus* Supino, *I. kuntzi* Hoogstraal & Kohls, *I. nipponensis* Kitaoka & Saito, *I. ovatus* Neumann, *I. persulcatus* Schulze, *I. simplex* Neumann, *I. vespertilionis* Koch, *Rhipicephalus haemaphysaloides* (Supino), and *R. sanguineus* (Latreille). An additional 13 tick species previously believed to occur in Taiwan are excluded from this list.

Key Words: ticks, Ixodida, checklist, synonymy, Taiwan

At least 11 papers and reports intended to serve as checklists of the ticks of Taiwan (formerly Formosa) and vicinity were published or privately circulated during the 20th century (Kishida 1935, Schulze 1935, Ogu-
ra 1936, Sugimoto 1939, Elishewitz 1943, Anonymous 1944, Luh and Woo 1950, Shimada et al. 1961, Maa and Kuo 1966, Tseng 1978, and Hoogstraal letter no. 251, 14 February 1984, Smithsonian Institution Archives). However, when these lists are critically compared, it soon becomes apparent that there are numerous disagreements among them. Most are also rife with nomenclatural or typographical errors or cite species names that have long since been

consigned to the junior synonymy. With the recent emergence of Lyme borreliosis and human babesiosis in Taiwan (Shih and Chao 1998, 1999; Shih et al. 1997, 1998), it is imperative that these lists be reconciled with current taxonomic literature and available specimen records to produce a single reliable roster of the Taiwan tick fauna.

Between 1955 and 1978, teams from U.S. Naval Medical Research Unit Number Two (NAMRU-2), Taipei, scoured Taiwan and its nearby islets (Lutao or Green Island, Lanyu or Orchid Island, and the Penghu archipelago), collecting vertebrates and invertebrates “to provide the biological knowledge required for controlling the animal and

insect vectors of area diseases" (Secretary of the Navy Notice 5450, 9 May 1955). Over 1,900 tick collections, each containing from one to hundreds of specimens, were shipped to the laboratory of the late Harry Hoogstraal (1917–1986), then Head, Medical Zoology Department, U.S. Naval Medical Research Unit Number Three (NAMRU-3), Cairo, Egypt, for identification and evaluation. After Hoogstraal's death, this vast resource was merged with the U.S. National Tick Collection (USNTC), now located at the Institute of Arthropodology and Parasitology, Georgia Southern University, Statesboro, while the voluminous correspondence pertaining to the Taiwan collections was archived at a Smithsonian Institution records center in Springfield, Virginia.

Since 1986, I have had several opportunities to examine critical Taiwanese specimens in the USNTC. With the assistance of Smithsonian archivists, I have also been able to peruse and photocopy key portions of the Hoogstraal correspondence files. The following tabulation comprises all 30 Taiwan tick species represented in the USNTC, plus two species known from Taiwanese specimens in the Bernice P. Bishop Museum (BPBM), Honolulu, Hawaii. Each species name appears in **boldface**, accompanied by 1) the total number of Taiwan-area collections of that species in, or recorded by, the USNTC or BPBM (some collections were not retained); 2) where applicable, a note on recent (and as yet controversial) classificatory changes advocated by Horak et al. (2002); and 3) a summary of all junior synonyms in earlier Taiwan checklists, or relevant remarks. I also comment on 13 tick species that, to my knowledge, do not occur in Taiwan, despite published reports or extant specimens suggesting their presence.

TICK SPECIES KNOWN TO OCCUR IN TAIWAN
AND ADJACENT ISLETS

Family Argasidae

***Argas pusillus* Kohls, 1950.**—13 Taiwan collections in USNTC. Now also classified

as *Carios pusillus* (Kohls, 1950) (Horak et al. 2002).

Junior synonymy in Taiwan checklists: None. Published references to *A. vespertilionis* (Latreille, 1796) in Taiwan (Kishida 1935, Sugimoto 1939, Shimada et al. 1961, Maa and Kuo 1966, Tseng 1978) may represent *A. pusillus*. Hoogstraal (letter no. 251, 14 February 1984) lists *A. vespertilionis* as occurring in Taiwan even though he earlier (letter no. 376, 14 February 1977) concluded that "all *A. vespertilionis* group samples from Taiwan . . . represent *A. pusillus*." On my copy of the Hoogstraal checklist, the words "*pusillus* Kohls" have been hand-entered above the typed listing for *A. vespertilionis*, but the latter name has not been altered.

***Argas robertsi* Hoogstraal, Kaiser & Kohls, 1968.**—1 Taiwan collection in USNTC.

Junior synonymy in Taiwan checklists: None. Published references to *A. persicus* (Oken, 1818) from Taiwan (Kishida 1935, Anonymous 1944, Luh and Woo 1950, Shimada et al. 1961, Maa and Kuo 1966, Tseng 1978) appear to be recapitulations of a mis-determined *Argas*. Tseng's (1978) reference to "*Argas* sp. nr. *arboreus* Kaiser, Hoogstraal & Kohls, 1964" (an African species) may represent the morphologically similar *A. robertsi*. See Hoogstraal et al. 1968a, 1975a, b.

***Ornithodoros capensis* Neumann, 1901.**—3 Taiwan collections in USNTC. Now also classified as *Carios capensis* (Neumann, 1901) (Horak et al. 2002).

Junior synonymy in Taiwan checklists: None. Early references to an "*Ornithodoros* sp." in Taiwan (Kishida 1935, Maa and Kuo 1966) may apply to this species, but the host listed by these authors, domestic swine, would be atypical for *O. capensis*, which in Taiwan is known only from sea-birds.

Family Ixodidae

***Amblyomma cordiferum* Neumann, 1899.**—31 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists: None. Listed only by Hoogstraal (letter no. 251, 14 February 1984). Voltzit and Keirans (2002) stated that this species occurs in Taiwan.

***Amblyomma geoemydae* (Cantor, 1847).**—3 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists: *Amblyomma formosanum* Schulze, 1933, probably a junior synonym of *A. geoemydae* (see Camicas et al. 1998), is the name used for this species in the checklists of Schulze (1935), Elishewitz (1943), Anonymous (1944), Luh and Woo (1950), and Shimada et al. (1961).

***Amblyomma helvolum* Koch, 1844.**—18 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists: None. Not in previous checklists, but Hoogstraal et al. (1968b) and Kolonin (1995) stated that this species occurs in Taiwan.

***Amblyomma testudinarium* Koch, 1844.**—46 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists: *Amblyomma yajimai* Kishida, 1935 (Kishida 1935, Elishewitz 1943, Anonymous 1944, Luh and Woo 1950, Shimada et al. 1961, Maa and Kuo 1966); *A. infestum taiwanicum* Schulze, 1935 (Schulze 1935, Elishewitz 1943, Luh and Woo 1950, Shimada et al. 1961). Note that Elishewitz (1943), Luh and Woo (1950) and Shimada et al. (1961) list both junior synonyms. As well, Elishewitz (1943), Anonymous (1944), Luh and Woo (1950), Shimada et al. (1961) and Maa and Kuo (1966) list the senior synonym *A. testudinarium*.

***Aponomma varanense* (Supino, 1897).**—3 Taiwan collections in USNTC. Now also classified as *Amblyomma varanense* (Supino, 1897) (Horak et al. 2002).

Junior synonymy in Taiwan checklists: None. First reported from the Penghu archipelago by Robbins (1996), who described this species' convoluted taxonomic history. Elishewitz (1943) lists *Amblyomma*

serpentinum Schulze, 1936, a junior synonym of *Aponomma fuscolineatum* (Lucas, 1847), from Taiwan, but *A. varanense* is the only *Aponomma* known from bona fide Taiwan-area specimens.

***Boophilus microplus* (Canestrini, 1888).**—932 Taiwan collections in USNTC. Now also classified as *Rhipicephalus (Boophilus) microplus* (Canestrini, 1888) (Horak et al. 2002).

Junior synonymy in Taiwan checklists: An abundant and widespread species in Taiwan, *B. microplus* has been recorded under numerous junior synonyms: *B. annulatus australis* (Fuller, 1899) (Elishewitz 1943, Anonymous 1944); *B. annulatus caudatus* (Neumann, 1897) (Kishida 1935, Ogura 1936, Elishewitz 1943, Anonymous 1944); *B. australis* (Fuller, 1899) (Luh and Woo 1950); *B. caudatus* (Neumann, 1897) (Luh and Woo 1950, Shimada et al. 1961); *B. (Uroboophilus) distans* Minning, 1934 (Schulze 1935, Elishewitz 1943, Anonymous 1944, Luh and Woo 1950, Shimada et al. 1961); *B. (Uroboophilus) sinensis* Minning, 1934 (Schulze 1935, Elishewitz 1943, Luh and Woo 1950); *Margaropus annulatus australis* (Fuller, 1899) (Sugimoto 1939); and *M. annulatus caudatus* (Neumann, 1897) (Sugimoto 1939). Note that several checklist authors list more than one synonym. In addition, Sugimoto (1939) lists *M. annulatus* (Say, 1821), a junior synonym of *B. annulatus* (Say, 1821), which does not occur in Taiwan.

***Dermacentor taiwanensis* Sugimoto, 1935.**—76 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists: *Indocentor bellulus* Schulze, 1935 (Schulze 1935, Elishewitz 1943, Anonymous 1944); *Dermacentor bellulus* (Schulze, 1935) (Luh and Woo 1950, Shimada et al. 1961, Maa and Kuo 1966, Tseng 1978).

***Haemaphysalis bandicota* Hoogstraal & Kohls, 1965.**—15 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists:

None. Listed only by Tseng (1978) and Hoogstraal (letter no. 251, 14 February 1984). Thought to have been introduced with bandicoot rats, *Bandicota indica* (Bechstein) (Rodentia: Muridae), during the Dutch occupancy of Taiwan (1624–1662) (Hoogstraal and Kohls 1965, Hoogstraal and Wassef 1973).

***Haemaphysalis canestrinii* (Supino, 1897).**—11 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists: None. Listed only by Hoogstraal (letter no. 251, 14 February 1984), who earlier recorded this species from Taiwan (Hoogstraal 1971).

***Haemaphysalis doenitzi* Warburton & Nuttall, 1909.**—22 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists: None. Not in previous checklists, but Hoogstraal and Wassef (1973) listed numerous collections of this species from Taiwan and Lanyu.

***Haemaphysalis flava* Neumann, 1897.**—4 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists: None. This species appears in all previous checklists except those of Kishida (1935) and Schulze (1935).

***Haemaphysalis formosensis* Neumann, 1913.**—27 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists: None. This common species appears in all previous checklists. Recorded by Neumann (1913) from dogs in Taiwan.

***Haemaphysalis hystricis* Supino, 1897.**—95 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists: *Haemaphysalis nishiyamai* Sugimoto, 1935 (Sugimoto 1939, Elishewitz 1943, Anonymous 1944, Luh and Woo 1950, Shimada et al. 1961, Maa and Kuo 1966). This species also appears as the senior synonym *H. hystricis* in all previous checklists, reflecting its prominence in the Taiwan tick fauna (Hoogstraal et al. 1965, 1973).

***Haemaphysalis kitaokai* Hoogstraal, 1969.**—1 Taiwan collection in USNTC.

Junior synonymy in Taiwan checklists: None. Listed only by Tseng (1978) and Hoogstraal (letter no. 251, 14 February 1984). The single USNTC collection (RML 16603) consists of two badly damaged females obtained by Sugimoto (1937a, b) that were initially determined by Hoogstraal (1962) as *H. aponommoides* Warburton, 1913 (a species of the central and eastern Himalayas), but later (Hoogstraal 1969) tentatively determined to represent *H. kitaokai*. The abundance of this species in southernmost Japan (Nakao and Takada 1997) also argues for its occurrence in Taiwan.

***Haemaphysalis mageshimaensis* Saito & Hoogstraal, 1973.**—71 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists: None. Listed only by Hoogstraal (letter no. 251, 14 February 1984), but recorded from numerous hosts in Taiwan, Lutao, and Lanyu (Hoogstraal and Santana 1974).

***Haemaphysalis ornithophila* Hoogstraal & Kohls, 1959.**—No Taiwan collections in USNTC, but 8 collections in BPBM.

Junior synonymy in Taiwan checklists: None. Listed only by Tseng (1978). First reported from Taiwan by Wilson (1970).

***Haemaphysalis phasiana* Saito, Hoogstraal & Wassef, 1974.**—16 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists: None. Listed only by Hoogstraal (letter no. 251, 14 February 1984). According to Saito et al. (1974), "the taxon *phasiana* may possibly be a subspecies of *doenitzi*"; these authors call for additional data to clarify the status of *H. phasiana* in Taiwan.

***Haemaphysalis taiwana* Sugimoto, 1936.**—49 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists: *Haemaphysalis cornigera taiwana* Sugimoto, 1936 (Elishewitz 1943, Luh and Woo

1950, Shimada et al. 1961, Maa and Kuo 1966, Tseng 1978).

***Haemaphysalis yeni* Toulmanoff, 1944.**—1 Taiwan collection in USNTC.

Junior synonymy in Taiwan checklists: None. Not previously listed as occurring in Taiwan. The single USNTC collection (RML 77868) consists of 15 nymphs and 2 larvae removed from a specimen of the lesser coucal, *Centropus bengalensis* (Hartlaub) (Cuculiformes: Cuculidae), on Lanyu, off Taiwan's southeastern coast. The presence of *H. yeni* in Japan's Ryukyu Islands and in Vietnam (Saito and Hoogstraal 1972) suggests that it also occurs in Taiwan.

***Ixodes acutitarsus* (Karsch, 1880).**—8 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists: None. This distinctive species, said to be the largest *Ixodes* in the world (Yamaguti et al. 1971), appears in all previous checklists except Ogura (1936).

***Ixodes granulatus* Supino, 1897.**—128 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists: None. Listed only by Tseng (1978) and Hoogstraal (letter no. 251, 14 February 1984). This abundant and widespread species was first reported from Taiwan by Wilson (1970).

***Ixodes kuntzi* Hoogstraal & Kohls, 1965.**—35 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists: None. Listed by Maa and Kuo (1966), Tseng (1978), and Hoogstraal (letter no. 251, 14 February 1984). This species is endemic to Taiwan.

***Ixodes nipponensis* Kitaoka & Saito, 1967.**—1 Taiwan collection in USNTC.

Junior synonymy in Taiwan checklists: None. Not previously listed as occurring in Taiwan. The single USNTC collection (RML 35386) consists of two females taken from domestic cattle in the vicinity of Taipei. Although these may have been introduced specimens, the presence of *I. nipponensis*

in southernmost Japan (Nakao and Takada 1997) suggests that this species also occurs in Taiwan.

***Ixodes ovatus* Neumann, 1899.**—83 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists: *Ixodes shinchikuensis* Sugimoto, 1937 (Elishewitz 1943, Anonymous 1944, Luh and Woo 1950 (as "*I. shinckikuensis*"), Shimada et al. 1961, Maa and Kuo 1966); *I. taiwanensis* Sugimoto, 1936 (Elishewitz 1943, Anonymous 1944, Luh and Woo 1950, Shimada et al. 1961, Maa and Kuo 1966). Note that both junior synonyms are listed in the same five checklists. The senior synonym *I. ovatus* is listed only by Tseng (1978) and Hoogstraal (letter no. 251, 14 February 1984).

***Ixodes persulcatus* Schulze, 1930.**—7 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists: None. Listed only by Hoogstraal (letter no. 251, 14 February 1984). Published references to *I. ricinus* (Linnaeus, 1758) in Taiwan (Sugimoto 1939, Elishewitz 1943, Anonymous 1944, Luh and Woo 1950, Shimada et al. 1961, Maa and Kuo 1966) almost certainly represent *I. persulcatus*, an eastern Palearctic sister species of the largely European *I. ricinus*. Uncommon in Taiwan tick collections, *I. persulcatus* is the principal vector of Lyme borreliosis in northeastern Asia and is probably responsible for the small number of cases now being reported in Taiwan (Shih et al. 1998, Shih and Chao 1999).

***Ixodes simplex* Neumann, 1906.**—53 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists: None. Listed only by Tseng (1978) and Hoogstraal (letter no. 251, 14 February 1984). Wilson (1970) first reported *I. simplex* from Taiwan.

***Ixodes vespertilionis* Koch, 1844.**—No Taiwan collections in USNTC, but 2 collections in BPBM.

Junior synonymy in Taiwan checklists:

None. Listed only by Tseng (1978). First reported from Taiwan by Wilson (1970).

***Rhipicephalus haemaphysaloides* (Supino, 1897).**—50 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists: *Rhipicephalus haemaphysaloides expeditus* Neumann, 1904 (Luh and Woo 1950); *R. expeditus* Neumann, 1904 (Shimada et al. 1961). The senior synonym *R. haemaphysaloides* is also listed by Shimada et al. (1961), as well as by Maa and Kuo (1966), Tseng (1978), and Hoogstraal (letter no. 251, 14 February 1984).

***Rhipicephalus sanguineus* (Latreille, 1806).**—47 Taiwan collections in USNTC.

Junior synonymy in Taiwan checklists: None. This ubiquitous species appears in all previous checklists. Hundreds of additional unaccessioned collections of *R. sanguineus* from Taiwan are in the USNTC.

EXCLUDED SPECIES

The preceding passages present arguments for excluding five tick species that appear in earlier checklists of the Taiwan fauna: *Argas persicus*, *A. vespertilionis*, *Aponomma fuscolineatum* (listed as the junior synonym *Amblyomma serpentinum*), *Boophilus annulatus* (listed as the junior synonym *Margaropus annulatus*), and *Ixodes ricinus*. Eight additional species named in these early checklists have either never occurred in Taiwan or are no longer present there:

Amblyomma breviscutatum Neumann, 1899.—Listed by Elishewitz (1943) and Anonymous (1944) as *A. cyprium* Neumann, 1899. Keirans, in Voltzit and Keirans (2002), determined that the types of these species are conspecific, and since *A. breviscutatum* has page priority over *A. cyprium*, the latter falls as a junior synonym. There are no Taiwan collections of *A. breviscutatum* in the USNTC. The single Taiwanese record cited in Robinson (1926) is from "Kankan," an alternate spelling of Kaohsiung (also formerly Koshung), Tai-

wan's second-largest city and its principal seaport, located in the tropical southwestern quadrant of the island. It is possible that *A. breviscutatum* either once occurred in Kaohsiung (or elsewhere on Taiwan's densely populated western coastal plain) and has since been extirpated by intense urbanization, or that living specimens were sporadically introduced with such hosts as cattle, horses, pigs and water buffalo imported from areas to the south and west that lie well within the range of this species (e.g., the Philippines, Indonesia).

Dermacentor atrosignatus Neumann, 1906.—Listed by Sugimoto (1939), Elishewitz (1943), Anonymous (1944), and Shimada et al. (1961). In their review of this Southeast Asian species, Hoogstraal and Wassef (1985) record specimens from Palawan, Busuanga, and Culion Island in the southwestern Philippines, localities far removed from Taiwan. A single supposedly Taiwanese collection of *D. atrosignatus* (1 ♂, 1 ♀) in the USNTC (RML 15189) has been lost (L.A. Durden, letter of 28 February 1997 to RGR). A malformed ♂, also alleged to be *D. atrosignatus*, from "Kosempo" (Chia-hsien, 23.05N, 120.35E, a town in Kaohsiung County), Taiwan, was discussed by Robinson (1920). It seems unlikely that this relatively large and conspicuously ornate *Dermacentor* would be overlooked in years of collecting by NAMRU-2 investigators.

Dermacentor reticulatus (Fabricius, 1794).—Listed by Maa and Kuo (1966) and by Tseng (1978). This western Palearctic species ranges no farther east than the Central Asian republics of the former Soviet Union (Pomerantsev 1950).

Haemaphysalis birmaniae Supino, 1897.—Listed by Kishida (1935), Schulze (1935), Elishewitz (1943), Anonymous (1944), Luh and Woo (1950), and Shimada et al. (1961). This species, "the subject of much taxonomic confusion and many incorrect host and distribution records" (Hoogstraal 1970), is known with certainty

only from northeastern India, Nepal and Myanmar (Burma).

Haemaphysalis bispinosa Neumann, 1897.—Listed by Elishewitz (1943), Anonymous (1944), Luh and Woo (1950), Shimada et al. (1961), and Tseng (1978). This is a tropical South Asian species (Hoogstraal and Trapido 1966); East Asian specimens of "*H. bispinosa*" are actually *H. longicornis* Neumann, 1901, a widespread and widely introduced tick whose original range embraced temperate areas of northeastern China, Korea, Japan, and maritime Russia (Hoogstraal et al. 1968c). Significantly, *H. longicornis* appears to be absent from the subtropical Ryukyu Islands (Yamaguti et al. 1971) and is therefore unlikely to occur as far south as Taiwan.

Haemaphysalis inermis Birula, 1895.—Listed by Elishewitz (1943), Anonymous (1944), Shimada et al. (1961), Maa and Kuo (1966), and Tseng (1978). This is another western Palearctic species, ranging from southern Europe to Turkey, southern Russia, and northern Iran (Hoogstraal 1969).

Haemaphysalis warburtoni Nuttall, 1912.—Listed by Kishida (1935), Schulze (1935), Sugimoto (1939), Elishewitz (1943), Luh and Woo (1950), Shimada et al. (1961), Maa and Kuo (1966), and Tseng (1978). All listings of *H. warburtoni* from Taiwan are apparently based on the single specimen reported by Nuttall and Warburton (1915) from "Taihoku" (Taipei); this specimen was restudied by Hoogstraal (1966) and found to be *H. formosensis*. True *H. warburtoni* is restricted to mountainous areas in southern China, Nepal, and northern India (Hoogstraal and Kim 1985).

Ixodes hexagonus Leach, 1815.—Listed by Sugimoto (1939), Elishewitz (1943), Shimada et al. (1961), Maa and Kuo (1966), and Tseng (1978). A third western Palearctic species, ranging across Europe and North Africa to western Russia and, perhaps, Central Asia (Arthur 1963).

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